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N02/420/H(3)M+

MARKSCHEME

November 2002

CHEMISTRY

Higher Level

Paper 3

16 pages

Subject Details: Chemistry HL Paper 3 Markscheme

General

- Each marking point is usually shown on a separate line or lines.
- Alternative answers are separated by a slash (/) – this means that either answer is acceptable.
- Words underlined are essential for the mark.
- Material in brackets (…) is not needed for the mark.
- The order in which candidates score marks does not matter (unless stated otherwise).
- The use of **OWTTE** in a markscheme (the abbreviation for "or words to that effect") means that if a candidate's answer contains words different to those in the markscheme, but which can be interpreted as having the same meaning, then the mark should be awarded.
- Please remember that many candidates are writing in a second language, and that effective communication is more important than grammatical accuracy.
- In some cases there may be more acceptable ways of scoring marks than the total mark for the question part. In these cases, tick each correct point, and if the total number of ticks is greater than the maximum possible total then write the maximum total followed by **MAX**.
- In some questions an answer to a question part has to be used in later parts. If an error is made in the first part then it should be penalised. However, if the incorrect answer is used correctly in later parts then "follow through" marks can be scored. Show this by writing **ECF** (error carried forward). This situation often occurs in calculations but may do so in other questions.
- Units for quantities should always be given where appropriate. In some cases a mark is available in the markscheme for writing the correct unit. In other cases the markscheme may state that units are to be ignored. Where this is not the case, penalise the omission of units, or the use of incorrect units, once only in the paper, and show this by writing **–1(U)** at the first point at which it occurs.
- Do not penalise candidates for using too many significant figures in answers to calculations, unless the question specifically states the number of significant figures required. If a candidate gives an answer to fewer significant figures than the answer shown in the markscheme, penalise this once only in the paper, and show this by writing **–1(SF)** at the first point at which this occurs.
- If a question specifically asks for the name of a substance, do not award a mark for a correct formula; similarly, if the formula is specifically asked for, do not award a mark for a correct name.
- If a question asks for an equation for a reaction, a balanced symbol equation is usually expected. Do not award a mark for a word equation or an unbalanced equation unless the question specifically asks for this. In some cases, where more complicated equations are to be written, more than one mark may be available for an equation – in these cases follow the instructions in the mark scheme.
- Ignore missing or incorrect state symbols in an equation unless these are specifically asked for in the question.
- Mark positively. Give candidates credit for what they have got correct, rather than penalising them for what they have got wrong.
- If candidates answer a question correctly, but by using a method different from that shown in the markscheme, then award marks; if in doubt consult your Team Leader

Option C – Human biochemistry

C1. (a) hypothalamus;
pituitary gland; ***[2]***

(b) (insulin) pancreas *(accept islets of Langerhans)*;
decreases glucose / sugar concentration in blood / helps conversion of glucose to glycogen;

(thyroxine) thyroid gland;
regulates metabolism / involved in control of heart rate / involved in temp regulation / role in calcium metabolism; ***[4]***

C2. (a) propane-1,2,3-triol / glycerol *(accept formula)*; ***[1]***

(b) (i) presence of one (or more) $C=C$ bonds / can undergo addition reactions;
(do not accept just double bonds) ***[1]***

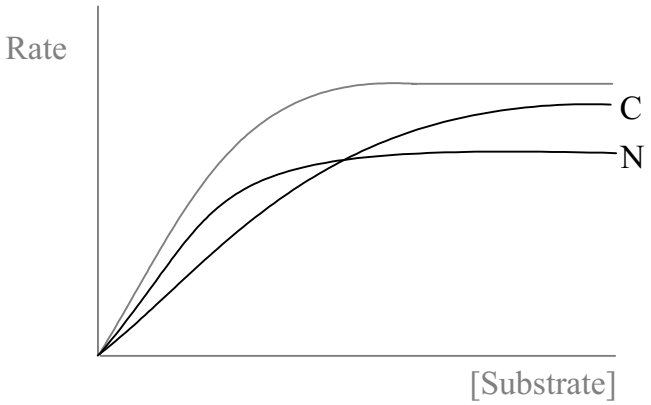
(ii) $C_{17}H_{35}COOH > C_{15}H_{31}COOH > C_{17}H_{31}COOH$; ***[1]***

(iii) van der Waals' forces;
(do not accept H-bonding as in this case the main attractive forces are vdWs') ***[1]***

(iv) (first pair) difference in M_r / chain length / area of contact;
(second pair) difference in bond angle / closeness of packing / area of contact; ***[2]***
Credit area of contact only once.

(c) $M_r(I_2) = 253.8 / 254$;
$I_2\ n = \left(\frac{0.254}{253.8}\right) = 0.001\ (\text{mol})$;
oil is monosaturated / has 1 $(C=C)$ double bond per molecule; ***[3]***
2 double bonds, based on use of $A_r = 126.9 / 127$ *scores* ***[2]***.

C3.



each curve = ***[1]***

competitive inhibitor (C) occupies active sites;
non-competitive inhibitor (N) changes enzyme's shape;
with C, original rate reached because substrate outnumbers C / *OWTTE*;
with N, original rate not reached because increased [substrate] does not restore shape of enzyme / *OWTTE*; ***[5 max]***
Any three of last four points ***[1]*** *each.*

C4. (electron transport)
cytochrome / cytochrome oxidase;
copper / iron;
metal ion undergoes change of oxidation number / is oxidized / reduced;
$Fe^{2+} \rightarrow Fe^{3+} + e^{-}$ / $Cu^{+} \rightarrow Cu^{2+} + e^{-}$ / reverse reaction / or with reversible arrow;
glucose is oxidized;
oxygen is reduced to water;
Any five of the above for ***[1]*** *each.*

OR
(oxygen transport)
haemoglobin;
iron (ion);
surrounded by 4 N atoms *(this mark can be scored for cytochrome oxidase instead)*;
at centre of haem group / porphyrin ring;
oxygen joins to iron;
reversibly;
acting as a ligand; ***[5 max]***
Any five of the above for ***[1]*** *each.*

Option D – Environmental chemistry

D1. (a) (formation) $O_2 \rightarrow 2O\bullet$;
$O\bullet + O_2 \rightarrow O_3$;
(depletion) $O_3 \rightarrow O_2 + O\bullet$;
$O_3 + O\bullet \rightarrow 2O_2$; ***[4]***
$\bullet$ *symbol not essential, ignore state symbols.*

(b) (i) chlorofluorocarbon *(ignore minor spelling errors)*;
spray cans / aerosols / propellants;
refrigerators / air conditioning;
solvents;
blowing agents;
fire extinguishers; ***[3 max]***
Any two uses for ***[1]*** *each.*

(ii) skin cancer;
(eye) cataracts;
genetic mutation; ***[2 max]***
Any two for ***[1]*** *each.*

(iii) flammable;
greenhouse gas / causes global warming; ***[2]***

D2. activated sludge process;
sedimentation tank / settling tank / trickle bed;
aeration / bubble air or oxygen through;
organic matter removed / oxidized / decomposed aerobically;
with the help of bacteria;
(some) sludge recycled / used as fertilizer; ***[4 max]***
Any four for ***[1]*** *each.*

D3. (a) city surrounded by hills / in bowl;
lack of wind / still air;
temperature / thermal inversion;
cold air below warm air;
pollutants do not disperse; ***[4 max]***
Any four for ***[1]*** *each.*

(b) species with unpaired / lone / single / odd electron;
$NO + \frac{1}{2}O_2 \rightarrow NO_2$;
$NO_2 \rightarrow NO + O$;
$O_2 + O \rightarrow O_3$; ***[4]***
Ignore state symbols and the radical symbol $\bullet$.

(c) alkanal / alkanone / PAN (peroxyacylnitrate);
irritation of eye / carcinogenic / damages crops; ***[2]***

Option E – Chemical industries

E1. (a) dried / water vapour removed / purified / carbon dioxide removed;
compressed / pressurized;
cooled; ***[3]***

(b) nitrogen / N_2 *(accept* N*)*; ***[1]***

(c) (nitrogen) freezing food / filling snack food packets / providing inert atmosphere in welding / flushing out oil tanks / other feasible use *(accept Haber process)*;
(oxygen) steel making / rocket propulsion / specified medical use / other feasible use; ***[2]***

E2. (a) (i) $C_{12}H_{26} \rightarrow C_8H_{18} + C_4H_8$ / $C_{12}H_{26} \rightarrow C_8H_{16} + C_4H_{10}$; ***[1]***

(ii) alumina / Al_2O_3 / silica / SiO_2 / zeolite; ***[1]***

(iii) alkene;
presence of hydrogen;
would add to $(C = C)$ double bonds (in alkenes); ***[3]***

(b) benzene and hydrogen *(both needed for mark)*;
$C_6H_{14} \rightarrow C_6H_6 + 4H_2$; ***[2]***

(c) isomerization;
cyclization; ***[2]***

E3. (a) ΔH is constant / varies (only) slightly;
If not scored here, mark can be scored in (b).
decrease in moles / volume of gas;
decrease in disorder / ΔS is negative;
correct reference to $T\Delta S^{\ominus}$ term, *e.g.* becomes more negative as *T* increases / $-T\Delta S^{\ominus}$ becomes more positive; ***[3 max]***

(b) (CO_2 formation) no change in moles / volume of gas;
(CO formation) increase in moles / volume of gas;
increase in disorder / ΔS is positive;
correct reference to $T\Delta S^{\ominus}$ term, *e.g.* becomes more positive as *T* increases / $-T\Delta S^{\ominus}$ becomes more negative; ***[3 max]***

E4. (a) (SiO_2) heated with carbon / coke;
Si reacted with Cl_2 / converted to $SiCl_4$;
$SiCl_4$ purified by distillation;
$SiCl_4$ reacted with Mg / H_2;
Si further purified by zone refining / crystallization; ***[4 max]***
*Any four for **[1]** each.*

Option F – Fuels and energy

F1. (a) plants / trees / vegetation;
buried under sediment / layers of rock;
compressed / pressurized;
heated;
for millions of years;
in the absence of oxygen / anaerobic conditions; ***[4 max]***
*Any four for **[1]** each.*

(b)

	Coal	Oil
advantages:	reserves greater; cheaper if mined near surface;	less polluting if sulfur removed;
disadvantages:	more pollution by acid rain / particulates; scars environment / *OWTTE*;	reserves less; greater cost of deep drilling / drilling under water / in hostile environments; pollution risk from oil spills at sea;

[5 max]

*Any five for **[1]** each, provided that at least two points refer to coal and two to oil. The point about reserves can be scored for only coal or oil.*

F2. (a) photosynthesis;
$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$; ***[3]***
*All formulas correct = **[1]**, correctly balanced = **[2]**.*

(b) fermentation;
$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$; ***[3]***
*All formulas correct = **[1]**, correctly balanced = **[2]**.*

F3. (a) ${}^{60}_{27}\text{Co} \rightarrow {}^{60}_{28}\text{Ni} + {}^{0}_{-1}\text{e}$;

time for isotope's activity / mass / concentration to decrease to half;

$\left(\text{k} = \dfrac{0.693}{\text{t}_{\frac{1}{2}}}\right) = \dfrac{0.693}{5.27} = 0.131\ \text{y}^{-1}$;

$\left(\ln\dfrac{\text{X}_0}{\text{X}} = \text{kt}\right) \ln\dfrac{100}{10} = 0.131\,\text{t},\ \text{t} = 17.6\ \text{y}$; ***[4]***

(b) (mass defect) - decrease in mass when atom formed from its sub-atomic particles / *OWTTE*;

(binding energy per nucleon) - energy needed to break nucleus into protons and neutrons divided by number of nucleons / *OWTTE*;

mass of lead-204 $= \dfrac{0.203973}{6.022\times10^{23}} = 3.387131\times10^{-25}$ kg;

mass defect $= 3.415015\times10^{-25} - 3.387131\times10^{-25} = 2.7884\times10^{-27}$ kg;

$(E = mc^2) = 2.7884\times10^{-27}\times(2.998\times10^{8})^2 = 2.5062\times10^{-10}$ J;

binding energy per nucleon $= \dfrac{2.5062\times10^{-10}}{204} = 1.23\times10^{-12}$ J; ***[6]***

Option G – Modern analytical chemistry

G1. (a) division of each percentage figure by relevant atomic mass to give values C = 4.05, H = 8.12, O = 2.70 *(accept use of whole-number atomic masses)*;
(empirical formula) $C_3H_6O_2$; ***[2]***

(b) (i) $C_3H_6O_2$; ***[1]***

(ii) due to presence of ^{13}C; ***[1]***

(iii) (29) $C_2H_5^+$; *(accept* CHO^+ *)*;
(45) HCO_2^+; *(accept* $COOH^+$ *or* $C_2H_5O^+$ *)*; ***[2]***
If a + charge is missing, penalize once only.

(c) (i) **C** is not an alkanol / alkanoic acid / does not contain an OH group; ***[1]***

(ii) (2950 cm^{-1}) C–H;
(1750 cm^{-1}) C=O;
(1180 cm^{-1}) C–O; ***[3]***
Allow correct word descriptions, e.g. "carbonyl" for C=O, "carbon to oxygen single bond" for C–O.

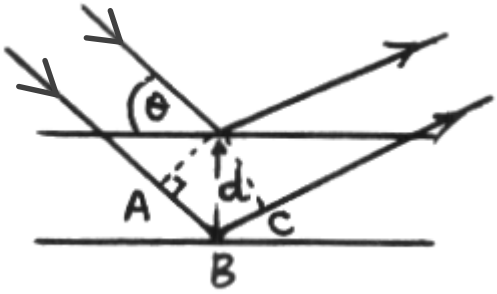
(d) (i) (triplet at 1.3) CH_3 / the hydrogens are next to a CH_2 group *(accept name)*;
(quartet at 4.3) CH_2 / the hydrogens are next to a CH_3 group *(accept name)*; ***[2]***
If only C_2H_5 *group mentioned, award* ***[1]****.*

(ii) there are no H atoms on the adjacent C atoms; ***[1]***

(e) (i) $HCOOCH_2CH_3$;
ethyl methanoate; ***[2]***

(ii) (compound **A**) methanoic acid;
(compound **B**) ethanol; ***[2]***
If correct names in wrong order, award ***[1]****.*

G2. (a) monochromatic X-rays / X-rays of known frequency / wavelength;
single crystal / powder;
sample rotated;
X-rays diffracted by electrons;
detected / recorded on (photographic) film;
*Any four of the above for **[1]** each.*



diffraction diagram suitably labelled;
extra distance travelled $= 2d\sin\theta$; ***[6]***

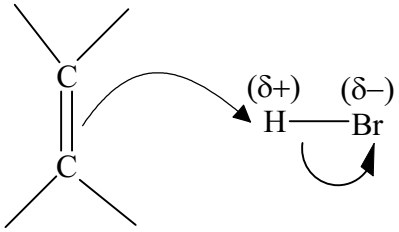
(b) (assuming $n = 1$) $\lambda = 2d\sin\theta$;

$$d = \frac{1.54\times10^{-10}}{2\times\sin 11^\circ} = 4.04\times10^{-10}\ \text{m};$$ ***[2]***

Option H – Further organic chemistry

H1. (a) (i) electrophilic addition; ***[1]***

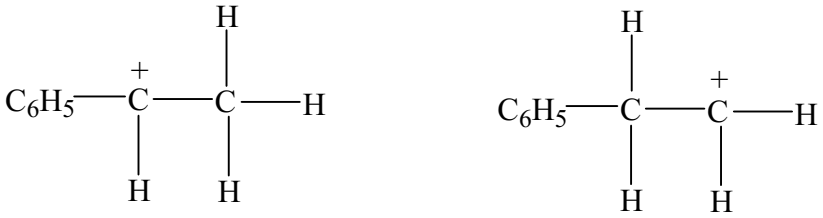
(ii) mechanism with two correct curly arrows;



(*both 'curly arrows' needed for mark*)

[1]

(iii)

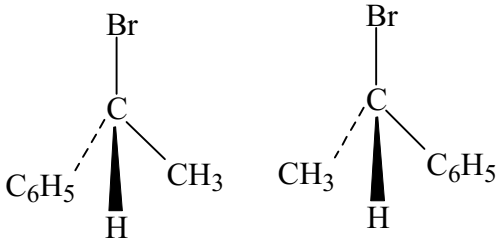


[2]

(***[1]*** *for each correct structure*)

(iv) correctly identifying intermediate carbocations as primary and secondary;
secondary more stable;
because charge is spread more evenly / extra electron- releasing (alkyl) group / greater positive inductive effect / *OWTTE;* ***[3 max]***

(b) (i)



one correct structural formula;
two non-superimposable 3-dimensional structures shown; ***[2]***

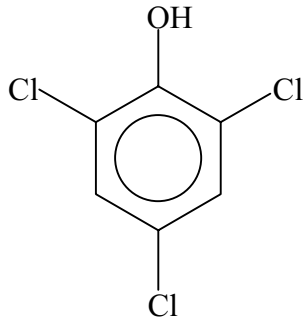
(ii) (physical) plane of polarization of polarized light rotated in opposite directions;
(chemical) no difference / chemical properties the same
(except with some optically active compounds); ***[2]***

H2. W and Z *(both needed for the mark, any other answer =* ***[0]****)*;
in W rotation is restricted by the (4-membered) ring;
in Z rotation is restricted by the double bond / π bond; ***[3]***

H3. (a) (I) halogen carrier / Friedel-Crafts catalyst / $AlCl_3$ / Fe ;
equation showing formation of Cl^+ and $AlCl_4^-$ / Cl---Cl---$AlCl_3$;
arrow showing attack by π electrons on Cl^+ / Cl---Cl---$AlCl_3$;
arrow showing loss of H^+ from intermediate;

(II) UV light;
equation showing formation of Cl• *(• symbol not essential)*;
equation showing 1st propagation step;
equation showing 2nd propagation step; ***[8]***

(b) phenol more reactive (than methylbenzene);
lone pair of electrons on O attracted into benzene ring / increases electron density of ring / extends (electron) delocalization of ring;



[3]